

METHOD FOR DESIGNING OF ELLIPTICAL STRUCTURE AND THE SAME

Field Of The Invention

The present invention relates to a method for designing of an elliptical structure, and the same.

Background

Conventional building structures are typically square, rectangular, and circular in horizontal section, and although some of them use walls having a variety of curves as outer walls and the like, structures which horizontal section is elliptical are not often encountered. If structures which outer walls partly adopts an elliptic curve can be encountered, those which are entirely elliptical in horizontal section, in other words, which entire perimeter forms an elliptical cylinder are rarely encountered. However, structures which horizontal section is elliptical are extremely graceful in shape, and have a high strength, therefore, as future building structures providing a novel feeling and a beautiful appearance, they can be greatly expected to be popularized.

Then, the present invention provides efficient and economic means for serving the design, drawing, land survey, manufacture, and construction in building an elliptical structure.

The elliptic curve is a quadratic curve which is characterized in that the sum of the distances from a particular point thereon to the two focuses of ellipse is constant. For drawing an elliptic curve, two coordinate points which are to be on the elliptic curve may be connected to each other with a single straight line as a convenient method, or with a polygonal line approximate to the elliptic curve as a more precise method. However, for connecting two coordinate points to each other with a polygonal line, the distance between the two coordinate points must be finely divided, and minute polygonal line components must be drawn, being connected to one another. Therefore, to connect two coordinate points by means of such a polygonal line to provide an approximate elliptic curve, complex computations and operations are required. Thus, using such an approximate elliptic curve which is thus obtained means that it requires intricate calculations and drawings in designing an elliptical structure, and that it is not efficient, economical, and feasible in land surveying on the building site for the elliptical structure, and fabricating member materials for the structure.

Summary Of The Invention

The present invention eliminates these problems by connecting circular

segments to provide an approximate elliptic curve. The locus of a circle is determined depending upon the center and the radius, and thus a circular segment can be easily drawn. Therefore, connecting circular segments to generate an approximate elliptic curve makes the design and drawing of elliptical structures substantially more efficient and provides feasible means for constructing elliptical structures.

The first purpose of the present invention is to provide an approximate elliptic curve for an elliptical structure by connecting circular segments.

The second purpose of the present invention is to provide a method for designing an elliptical structure efficiently, economically, and practically by connecting circular segments to generate an approximate elliptic curve.

The third purpose of the present invention is to provide an elliptical structure which can be efficiently, economically and practically designed by connecting circular segments to generate an approximate elliptic curve.

These purposes can be achieved by the present invention, which embodiments will be described here with reference to the accompanying drawings. It is needless to say that any possible modifications and variations of the present invention can be covered by the claims which are later given.

As shown in the accompanying drawings which are described later, the present invention provides the following items [1], [2], and [3]:

[1] A method for designing an elliptical structure (A) which is symmetrical about the major axis (M) and the minor axis (N) thereof, and has an outline (B_1) of an approximate elliptic curve, comprising the steps of:

a) establishing a first fixed point (C_1) outside the elliptical structure (A); from the first fixed point (C_1), drawing a straight line segment (L_0) to the farthest end point of the minor axis (N) through the intersecting point (o) of the major axis (M) and the minor axis (N); and drawing a first circular segment (d_1) from said farthest end point (P_0) of the minor axis (N) with the use of the first fixed point (C_1) as the center and the first straight line segment (L_1) having the same length as that of said straight line segment (L_0) as the radius, through an arbitrary angle α_1 set at said first fixed point (C_1);

b) establishing a second fixed point (C_2) on said first straight line segment (L_1); and drawing a second circular segment (d_2) following said first circular segment (d_1) with the use of the second fixed point (C_2) as the center and the second straight line segment (L_2) as the radius, through an arbitrary angle α_2 set at said second fixed point (C_2);

c) establishing a third fixed point (C_3) on said second straight line segment (L_2); and drawing a third circular segment (d_3) following said second circular segment (d_2) with the use of the third fixed point (C_3) as the center and the third straight line segment (L_3) as the radius, through an arbitrary angle α_3

5 set at said third fixed point (C_3);

d) repeating this step as required;

e) finally drawing an n th circular segment (d_n) following $(n - 1)$ th circular segment (d_{n-1}) and ranging from the finish end (P_{n-1}) of the $(n - 1)$ th circular segment (d_{n-1}) to the major axis (M) with the use of the intersecting point (C_n) of
10 $(n - 1)$ th straight line segment (L_{n-1}) and the major axis (M) as the center, and a part of the $(n - 1)$ th straight line segment (L_{n-1}) as the radius; and

f) using these steps to draw a part of the outline (B_1) in each of the other quadrants for drawing the entire outline (B_1).

[2] A method for designing an elliptical structure (A) which is symmetrical
15 about the major axis (M) and the minor axis (N) thereof, and has an outline (B_2) of an approximate elliptic curve, comprising the steps of:

a) establishing a first fixed point (C_1) outside the elliptical structure (A); from the first fixed point (C_1), drawing a straight line segment (L_0) to the farthest end point (P_0) of the minor axis (N) through the intersecting point (o) of the major axis (M) and the minor axis (N); and drawing a first circular segment (d_{10}) from
20 said farthest end point (P_0) of the minor axis (N) with the use of the first fixed point (C_1) as the center and a first straight line segment (L_{10}) having the same length as the straight line segment (L_0) as the radius, through an arbitrary angle α_1 set at said first fixed point (C_1);

25 b) establishing a second fixed point (C_{20}) on said first straight line segment (L_{10}); and drawing a second circular segment (d_{20}) following said first circular segment (d_{10}) with the use of the second fixed point (C_{20}) as the center and the second straight line segment (L_{20}) as the radius, through an arbitrary angle α_2 set at said second fixed point (C_{20});

30 c) finally drawing a third circular segment (d_{30}) following the second circular segment (d_{20}) and ranging from the finish end (P_{20}) of the second circular segment (d_{20}) to the major axis (M) with the use of the intersecting point (C_{30}) of the second straight line segment (L_{20}) and the major axis (M) as the center, and a part of the second straight line segment (L_{20}) as the radius; and

35 d) using these steps to draw a part of the outline (B_2) in each of the other quadrants for drawing the entire outline (B_2).

[3] An elliptical structure (A) which has an outline (B_1), (B_2) of an approximate elliptic curve, being constructed using building materials designed by the method as mentioned in either of the item [1] and item [2].

Brief Description Of The Drawings

FIG. 1 shows a bird's eye view of an elliptical structure (A) to be built on the present invention;

Fig. 2 is an example of elliptic curve drawn for the elliptical structure as shown in Fig. 1;

Fig. 3 shows an embodiment of the method for designing an elliptical structure according to the present invention; and

Fig. 4 shows another embodiment of the method for designing an elliptical structure according to the present invention.

Description Of The Preferred Embodiment

FIG. 1 shows a bird's eye view of an elliptical structure (A) to be built on the present invention. Fig. 2 is an example of elliptic curve drawn for the elliptical structure (A) as shown in Fig. 1, which outline or perimeter basically forms an ellipse, the elliptic curve being provided as a result of mathematical computation made by manual operation or by using such means as a computer. The elliptic curve has a major axis (M) and a minor axis (N) on the coordinate axes x and y (providing center lines), respectively, a partial outline (b_1), (b_2), (b_3), and (b_4) in the first quadrant (I), the second quadrant (II), the third quadrant (III), and the fourth quadrant (IV), respectively, being connected to one another to provide a complete outline (B) which forms an ellipse, and the elliptic curve is symmetrical about the major axis (M) and also about the minor axis (N).

Thus, with the present invention, the elliptic curve for the elliptical structure (A) is provided by connecting circular segments to one another.

Specifically, as shown in Fig. 3, an outline (B_1) approximating said outline (B) is created by connecting circular segments to one another. In other words, the major axis (M) and the minor axis (N) for the outline (B_1), i.e., the coordinate axes x and y are established, and a first fixed point (C_1) is established on the coordinate axis y. By drawing a straight line segment (L_0), which has a length equal to half the length of the previously established minor axis (N) plus the length from the first fixed point (C_1) to the major axis (M), i.e., the origin (o), which is the intersecting point of the major axis (M) and the minor axis (N), a point (P_0) which must exist on the outline (B_1) is determined. An angle α_1 is

set at said first fixed point (C_1), and a first circular segment (d_1) is drawn from the point (P_0) to a point (P_1) with the first fixed point (C_1) being used as the center, and a first straight line segment (L_1), which length is set at the same as the length of the straight line segment (L_0), being used as the radius. In this context, the point (P_1) provides a point where a first tangent line segment (k_1) at the end of the first circular segment (d_1) forms a right angle with the first straight line segment (L_1), in other words, an angle γ_1 at the point (P_1) is 90 deg. The first circular segment (d_1) drawn provides the partial outline (b_1) as mentioned above.

Next, a point distant from the first fixed point (C_1) by an arbitrary length ℓ_1 is established as a second fixed point (C_2) on the first straight line segment (L_1); an angle of α_2 is set to draw a second straight line segment (L_2) to a point (P_2); and with the second fixed point (C_2) being used as the center, and the second straight line segment (L_2) being used as the radius, a second circular segment (d_2), which follows the first circular segment (d_1), is drawn to the point (P_2). The beginning of the second circular segment (d_2) provides a point where a second tangent line segment (k'_1) at the start end of the second circular segment (d_2) forms a right angle with the first straight line segment (L_1), in other words, an angle γ'_1 at the point (P_1) is 90 deg. Thus, the angle γ_1 plus the angle γ'_1 is equal to 180 deg, and at the point (P_1), the first tangent line segment (k_1) for the first circular segment (d_1) and the second tangent line segment (k'_1) at the start end of the second circular segment (d_2) form a straight line segment, thereby the first circular segment (d_1) drawn previously and the second circular segment (d_2) drawn subsequently are smoothly and curvedly connected to each other with no offset being produced.

Next, a point distant from the second fixed point (C_2) by an arbitrary length ℓ_2 is established as a third fixed point (C_3) on the second straight line segment (L_2); an angle of α_3 is set to draw a third straight line segment (L_3) to a point (P_3); and with the third fixed point (C_3) being used as the center, and the third straight line segment (L_3) being used as the radius, a third circular segment (d_3), which follows the second circular segment (d_2), is drawn to the point (P_3). The beginning of the third circular segment (d_3) provides a point where a third tangent line segment (k_2) at the finish end of the second circular segment (d_2) and a fourth tangent line segment (k'_2) at the start end of the third circular segment (d_3) form a right angle with the second straight line segment (L_2), respectively, in other words, an angle γ_2 , γ'_2 at the point (P_2) is 90 deg. Thus,

the angle γ_2 plus the angle γ'_2 is equal to 180 deg, and at the point (P_2), the third tangent line segment (k_2) for the second circular segment (d_2) and the fourth tangent line segment (k'_2) for the third circular segment (d_3) form a straight line segment, thereby the second circular segment (d_2) drawn previously and
5 the third circular segment (d_3) drawn subsequently are smoothly and curvedly connected to each other with no offset being produced.

Next, a point distant from the third fixed point (C_3) by an arbitrary length ℓ_3 is established as a fourth fixed point (C_4) on the third straight line segment (L_3); an angle of α_4 is set to draw a fourth straight line segment (L_4) to a point (P_4); a
10 point where the major axis (M) intersects with the fourth straight line segment (L_4) is established as a fifth fixed point (C_5), which is the final fixed point; and a fifth circular segment (d_5), which follows the fourth circular segment (d_4), is drawn to the major axis (M) to provide a point (P_5). By this, one end of the major axis (M) is actually established. The angle which the third straight line
15 segment (L_3) forms with tangent line segments at the point (P_3) and that which the fourth straight line segment (L_4) forms with tangent line segments at the point (P_4) are 180 deg (as a result of 90 deg plus 90 deg), respectively, as is the case at the point (P_2). In this way, a partial outline (b_1) is sequentially formed in the first quadrant (I) for the outline (B_1).

20 If the values of angles α_1 , α_2 , α_3 , and α_4 , and the values of lengths ℓ_1 , ℓ_2 , and ℓ_3 are given, the values of lengths ℓ_4 and ℓ_5 can be determined by calculation (as later described). Then, as can be easily conjectured from Fig. 4 (although this figure illustrates another embodiment of the present invention), the same technique is used to draw a partial outline (b_2) at left of the first fixed
25 point (C_1) in the second quadrant (II) for the outline (B_1), and for the third quadrant (III) and the fourth quadrant (IV), a fixed point (C'_1) is established at the point symmetrical to the first fixed point (C_1), and by the same technique, partial outlines (b_3) and (b_4) are drawn. Now, said entire outline (B_1) has been formed by these partial outlines (b_1), (b_2), (b_3) and (b_4). By increasing the
30 number of angles α , as α_1 , α_2 , α_3 , α_4 , and α_5, \dots , and the number of straight line segments L , as L_1 , L_2 , L_3 , and L_4, \dots , the deviation of the components of the outline (B_1) from the corresponding components of the real elliptic curve can be decreased, in other words, the precision of the outline (B_1) created can be enhanced.

35 In Fig. 3, the length of the straight line segment (L_0) is equal to the distance between the first fixed point (C_1) and the point (P_0); the length of the first straight

line segment (L_1) is equal to the distance between the first fixed point (C_1) and the point (P_1); the length of the second straight line segment (L_2) is equal to the distance between the second fixed point (C_2) and the point (P_2); the length of the fourth straight line segment (L_4) is equal to the distance between the fourth fixed point (C_4) and the point (P_4); (although it is not indicated in the figure), the length of the n th straight line segment (L_n) is equal to the distance between the n th fixed point (C_n) and the point (P_n); and the intersecting point of the major axis (M) and the $(n - 1)$ th straight line segment (L_{n-1}) provide the n th fixed point (C_n), which is the final fixed point.

Further, in Fig. 3, the length ℓ_1 is equal to the distance between the first fixed point (C_1) and the second fixed point (C_2); the length ℓ_2 is equal to the distance between the second fixed point (C_2) and the third fixed point (C_3); the length ℓ_3 is equal to the distance between the third fixed point (C_3) and the fourth fixed point (C_4); the length ℓ_4 is equal to the distance between the fourth fixed point (C_4) and the fifth fixed point (C_5); and here the distance between the fifth fixed point (C_5) and the point (P_4) is equal to the distance between the fifth fixed point (C_5) and the point (P_5), therefore, the length of the fifth straight line segment (L_5) is equal to the length ℓ_5 . Here, the length of the fifth straight line segment (L_5) is equal to the distance between the fifth fixed point (C_5) and the point (P_5), which is equal to the length of the fourth straight line segment (L_4) minus the length ℓ_4 . The fifth fixed point (C_5) is said final fixed point, which provides the intersecting point of the fourth straight line segment (L_4) drawn from the fourth fixed point (C_4) and the major axis (M). By drawing a fifth circular segment (d_5), which follows the fourth circular segment (d_4), from the point (P_4) to the major axis (M), with the fifth fixed point (C_5) being used as the center, said point (P_5) is provided. Thereby, as stated above, the partial outline (b_1) is completed in the first quadrant. Here, if a straight line segment (s) which is parallel to the y axis is drawn from the fourth fixed point (C_4) toward the x axis, the angle θ formed between the straight line segment (s) and the fourth straight line segment (L_4) is equal to the sum of the angles α_1 , α_2 , α_3 , and α_4 .

Hereinbelow, it will be described that, by arbitrarily determining the distance between the first fixed point (C_1) and the point (P_0), the distance between the first fixed point (C_1) and the origin (o), half the length of the minor axis (N), i.e., $[N/2]$, the lengths ℓ_1 , ℓ_2 , and ℓ_3 , the angles α_1 , α_2 , α_3 , and α_4 , the lengths ℓ_4 and ℓ_5 can be determined. In Fig. 3, it is assumed that the intersecting point of a straight line drawn from the second fixed point (C_2) in

parallel with the x axis and intersecting with the y axis is E_1 , the distance between the first fixed point (C_1) and E_1 is ℓ'_1 ; the intersecting point of a straight line drawn from the third fixed point (C_3) in parallel with the x axis and intersecting with the y axis is E_2 , the distance between E_1 and E_2 is ℓ'_2 ; and the intersecting point of a straight line drawn from the fourth fixed point (C_4) in parallel with the x axis and intersecting with the y axis is E_3 , the distance between E_2 and E_3 is ℓ'_3 . Then, ℓ'_2 is equal to the distance between E_1 and E_2 ; ℓ'_3 is equal to the distance between E_2 and E_3 ; and ℓ'_4 is equal to the distance between E_3 and the origin (o). Here is a description using mathematical expressions.

$$\cos \alpha_1 = \frac{\ell'_1}{\ell_1}$$

$$\ell_1 = \frac{\ell'_1}{\cos \alpha_1} \quad \ell'_1 = \ell_1 \cos \alpha_1 \dots\dots\dots (1)$$

$$\ell_2 = \frac{\ell'_2}{\cos (\alpha_1 + \alpha_2)} \quad \ell'_2 = \ell_2 \cos (\alpha_1 + \alpha_2) \dots\dots\dots (2)$$

$$\ell_3 = \frac{\ell'_3}{\cos (\alpha_1 + \alpha_2 + \alpha_3)} \quad \ell'_3 = \ell_3 \cos (\alpha_1 + \alpha_2 + \alpha_3) \dots\dots (3)$$

If $C_{1,0}$ denotes the distance between C_1 and o, and P_0, C_1 the distance between P_0 and C_1 ,

$$C_{1,0} = P_0, C_1 - N/2$$

is a known number, and ℓ'_1 , ℓ'_2 , and ℓ'_3 can be calculated from the above equations (1), (2), and (3), thus, ℓ'_4 can be determined from the equation:

$$\ell'_4 = C_{1,0} - \ell'_1 - \ell'_2 - \ell'_3$$

Then, by the equation:

$$\cos \theta = \frac{\ell'_4}{\ell_4}$$

the value of ℓ_4 can be determined as follows:

$$\ell_4 = \frac{\ell'_4}{\cos \theta}$$

where θ is expressed by the following equation:

$$\theta = \alpha_1 + \alpha_2 + \alpha_3 + \alpha_4$$

Then, the length of the fourth straight line segment (L_4) is equal to the length of the straight line segment (L_0) minus $(\ell_1 + \ell_2 + \ell_3)$, and ℓ_5 is equal to the length of L_4 minus ℓ_4 , thus, the value of ℓ_5 can be calculated.

The length of the n th straight line segment (L_n), where $n \geq 2$, is equal to the length of the $(n - 1)$ th straight line segment (L_{n-1}) minus ℓ_{n-1} , where ℓ_{n-1} is expressed by the following equation:

$$\ell_{n-1} = \frac{\ell'_{n-1}}{\cos (\alpha_1 + \alpha_2 + \dots + \alpha_{n-1})}$$

Fig. 4 shows another embodiment. In Fig. 4, to create an outline (B_2) which approximate said outline (B), the major axis (M) and the minor axis (N) for the outline (B_2) of a building (A), i.e., the coordinate axes x and y are established; a first fixed point (C_1) is established on the coordinate axis y ; by drawing a straight line segment (L_0), which has a length equal to half the length of the previously established minor axis (N) plus the length from the first fixed point (C_1) to the major axis (M), i.e., the origin (o), which is the intersecting point of the major axis (M) and the minor axis (N), a point (P_0) which must exist on the outline (B_2) is determined; an angle α_1 is set at said first fixed point (C_1); a first circular segment (d_{10}) is drawn from the point (P_0) to a point (P_{10}) with the first fixed point (C_1) being used as the center, and a first straight line segment (L_{10}), which length is set at the same as the length of the straight line segment (L_0),

being used as the radius. The point (P_{10}) provides a point where an angle γ_1 at the point (P_{10}) is 90 deg, in other words, a first tangent line segment (k_{10}) at the end of the first circular segment (d_{10}) forms a right angle with the first straight line segment (L_{10}).

5 Next, a point distant from the first fixed point (C_1) by an arbitrary length ℓ_{10} is established as a second fixed point (C_{20}) on the first straight line segment (L_{10}); An angle of α_2 is set to draw a second straight line segment (L_{20}) to a point (P_{20}); and with the second fixed point (C_{20}) being used as the center, and the second straight line segment (L_{20}) being used as the radius, a second
10 circular segment (d_{20}), which follows the first circular segment (d_{10}), is drawn to the point (P_{20}). The beginning of the second circular segment (d_{20}) provides a point where a second tangent line segment (k'_{10}) at the start end of the second circular segment (d_{20}) forms a right angle with the first straight line segment (L_{10}), in other words, an angle γ'_1 at the point (P_{10}) is 90 deg. Thus, the angle γ_1
15 plus the angle γ'_1 is equal to 180 deg, and at the point (P_{10}), the first tangent line segment (k_{10}) for the first circular segment (d_{10}) and the second tangent line segment (k'_{10}) at the start end of the second circular segment (d_{20}) form a straight line segment, thereby the first circular segment (d_{10}) drawn previously and the second circular segment (d_{20}) drawn subsequently are smoothly and
20 curvedly connected to each other with no offset being produced.

Also at the point (P_{20}), the angle γ_2 plus the angle γ'_2 is equal to 180 deg, and at the point (P_{20}), a third tangent line segment (k_{20}) for the second circular segment (d_{20}) and a fourth tangent line segment (k'_{20}) at the start end of a third circular segment (d_{30}) (later described) form a straight line segment, thereby the
25 second circular segment (d_{20}) drawn previously and the third circular segment (d_{30}) drawn subsequently are smoothly and curvedly connected to each other with no offset being produced.

In this case, the second circular segment (d_{20}) intersects with the major axis at an angle of α_3 , and the sum of the angles α_1 , α_2 , and α_3 is equal to 90° .
30 By using this intersecting point as a third fixed point (C_{30}) (the final fixed point), the third circular segment (d_{30}), which follows the second circular segment (d_{20}), is drawn to the major axis (M). Thereby, one end of the major axis (M), i.e., a point (P_{30}), is determined. In this way, a partial outline (b_1) is sequentially formed in the first quadrant (I) for the outline (B_2).

35 In Fig. 4, the length of the straight line segment (L_0) is equal to the distance between the first fixed point (C_1) and the point (P_0); the length of the first straight

line segment (L_{10}) is equal to the distance between the first fixed point (C_1) and the point (P_{10}); and the length of the second straight line segment (L_{20}) is equal to the distance between the second fixed point (C_{20}) and the point (P_{20}). Therefore, if the values of angles α_1 and α_2 , and the value of length ℓ_{10} are given, the length of the second straight line segment (L_{20}) is determined, and the values of lengths ℓ_{20} and ℓ_{30} can be determined by calculation. In other words, if the third fixed point (C_{30}) is established, the length ℓ_{20} can be determined, and thus the length ℓ_{30} can be determined from the relationship: the length ℓ_{30} is equal to the length of the second straight line segment (L_{20}) subtracted by the length ℓ_{20} .

Thus, also in the present embodiment, the elliptic curve for an elliptical structure (A) can be formed by connecting circular segments to one another.

Then, as shown in Fig. 4, the same technique is used to draw a partial outline (b_2) at left of the first fixed point (C_1) in the second quadrant (II) for the outline (B_2), and for the third quadrant (III) and the fourth quadrant (IV), a fixed point (C'_1) is established at the point symmetrical to the first fixed point (C_1), and by the same technique, partial outlines (b_3) and (b_4) are drawn. Now, said entire outline (B_2) has been formed by these partial outlines (b_1), (b_2), (b_3) and (b_4).

Thus, with the present invention, the members based on the first circular segment (d_1) to the fifth circular segment (d_5), and the first circular segment (d_1) to the third circular segment (d_3) as shown in Figs. 3 and 4, respectively, are individually designed and manufactured to be connected to one another for creating building materials for all the four quadrants, which are then assembled to one another to provide a particular floor of the elliptical structure (A), and all the floors are jointed to one another to provide an entire elliptical structure (A).

The present invention can provide efficient and economic means for serving the design, drawing, land survey, manufacture, and construction in building an elliptical structure on a particular site. The present invention allows forming the outline of an elliptical structure by connecting circular segments while smoothly forming the joint of the respective circular segments, and makes it possible to perform the related computation by setting the radii of the respective circular segments and the required angles, thus permitting efficient construction of elliptical structures. Such elliptical structures are excellent in structural strength, durable, and helpful to prevent strong wind blowing along a street of highrise buildings.